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ABSTRACT

Prepared for a 1984 Organisation for Economic Cooperation and Development (OECD) conference, this report addresses the necessary reform of educational systems and the cost of new information technologies and their efficiency in education. A discussion of trends in public expenditures for education includes a review of trends since 1970 in OECD countries, the structure of expenditure, and trends in public educational effort. The need for and problems in improving efficiency in education are considered, including the growing inefficiency of the traditional system, the relative failure of the "old" new technologies, and the potential efficiency of the new information technologies. Costs of these technologies are discussed in the context of: (1) methods and problems in measuring costs; and (2) the information content and shortcomings of available data. The supposed advantages of the new information technologies are reviewed, as well as the findings of evaluation studies, efficient use of the new technologies, and the external effects of their introduction in education. The principal outstanding problems are reviewed in the concluding statement and recommendations are made for cost studies, measurements of efficiency, and cost effectiveness studies. Notes and references and a paper on the problems of measuring education costs and methodological choices are included. (MBR)

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ECONOMIC ASPECTS OF THE INTRODUCTION OF NEW INFORMATION TECHNOLOGIES IN EDUCATION

(Note by the Secretariat)

1. The attached report, has been prepared by Jean Claude Eicher, Director of the Institut de recherche sur l'économie de l'éducation (IREDU), France, in his capacity as consultant to the Secretariat. It will serve as a background report for the Plenary Session on Theme 2 and in Working Groups 1 and 5:

2. The views expressed in this document are those of the author and do not commit either the Organisation or the national authorities concerned.

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Table of contents

INTRODUCTION

		Paragraphs
Chapitre I :	THE NECESSARY REFORM OF EDUCATION SYSTEMS	7-36
A.	Trends in Education Expenditure and the Consequences thereof	9-18
	1. General Trends in Public Expenditure on Education	10-12
	a) General Trends since 1960 b) Trends since 1970 in OECD countries	
	2. Structure of Expenditure	13-14
	3. Trends in the Public Educational Effort	15-18
	a) Parameter Selection Problems b) Trend in Expenditure per Pupil c) Expenditure as a Percentage of GNP	
B.	Improving Education Efficiency -- Problems and Needs	19-36
	1. Growing Inefficiency of the Traditional System	20-25
	a) Rising Costs b) Falling Efficiency	
	2. Relative Failure of the "Old" New Technologies	26-33
	a) On the whole, the impact on costs was not positive b) The efficiency of the programmes actually implemented has seldom clearly exceeded that of traditional education	
	3. Potential Efficiency of NIT	34-36

	Paragraphes
Chapitre II : THE COST OF NEW INFORMATION TECHNOLOGIES IN EDUCATION	37-75
A. Measuring Costs -- Methods and Problems	39-50
1. Form of the Production Function in an Education System based on Modern Technologies and its Impact on Cost Structure and Trends	41-46
2. Cost, Expenditure and Financing	47-50
B. Data on Costs -- Information Content and Shortcomings	51-75
1. Cost of the Different Phases of Transmitting the "Educational Message"	52-67
2. Total Cost Calculation and Comparison -- Problems and Limitations	68-75
Chapitre III : THE EFFICIENCY OF NEW INFORMATION TECHNOLOGIES IN EDUCATION	76-133
Section 1 : Increasing the Efficiency of the Traditional Education System	78-90
A. The Supposed Advantages of NIT	79-84
1. The learning process is facilitated and accelerated	80
2. The pupil's interest in school is increased	81
3. Teachers' assessment tasks are eased	82
4. The teacher can devote himself entirely to "noble" tasks	83
5. The management of teaching establishments is facilitated	84
B. The Findings of Evaluation Studies	85-90
1. The Effect of New Technologies on Knowledge Acquisition	86
2. The Effect on Reasoning Powers	87
3. The Effect on Pupil Attitudes	88
4. The Effect on Teachers	89-90

		Paragraphes
Section 2 :	The Extension of Educational Activities thanks to NIT	91-117
A.	Potential Advantages of NIT	92-101
	1. NIT can substantially enrich traditional teaching	93-94
	2. NIT allow the development of teaching hitherto impossible	95-96
	3. NIT should permit the development of many forms of extra-school training	97-101
B.	Efficient use of NIT -- Conditions Required and Limitations	102-117
	1. Environmental Conditions required for Effective use of NIT	103-112
	2. Limits on and Possible Dangers of the Large-Scale Introduction of NIT in Education	113-117
Section 3 :	The External Effects of Introducing NIT in Education	118-121
A.	Training within the Traditional Educational System	119
B.	Training Outside the Traditional Educational System Leading to a Diploma	120
C.	Non-dimploma Courses for Further Training or Personal Satisfaction	121
Conclusion		122
GENERAL CONCLUSIONS		123-133
	Outstanding Problems	124-133
	Cost-effective Studies	133
NOTES AND REFERENCES		
Annexe 1 :	The Problems of Measuring Education Costs and the Necessary Methodological Choices	
Annexe 2 :	Trends in Government Expenditure on Education (% of GNP spent on Public Education) in Selected OECD Countries (1970-81)	

INTRODUCTION

1. It is now fifteen years since Philip Coombs predicted, in what has remained a best-seller, the "world crisis in education". During the 1970s, following the "period of elation" described by Thorsten Husen, doubts began to spread about the benefits of expanding educational systems. Worries caused by the excessively fast rise in the financial burden on public budgets were compounded by the doubts raised by the development of graduate unemployment.

2. In the developing countries, increasingly sharp criticism was heard about the unsuitability of curricula and syllabus contents for local requirements and lifestyles. In industrialised countries, from the onset of the world economic crisis, those hardest hit by unemployment were in practically every case school leavers without any academic qualifications or real vocational training. Whilst this observation in a way tended to reinforce belief in the economic benefits of qualifications, it also called into question the capacity of traditional education systems to provide all young persons with training to match their capabilities and meet society's needs.

3. Moreover, new requirements were emerging or expanding. There was a sharp rise in the number of adults wishing to supplement or complete their training or start afresh, either to improve their employment or career prospects or to make better use of their leisure time. "Marginal" groups (the handicapped, the sick, immigrants and their families, etc.) found better recognition of their specific needs. In short, doubts were being voiced about the ability of traditional educational systems, which had retained more or less the same organisation for many decades, to effectively meet all the demands made of them.

4. In view of the growing costs per pupil and the lack of correspondance between the services supplied and actual requirements, economists are tempted to argue in terms of productivity and seek optimum production techniques. However, education is not an ordinary market product. Indeed, it is difficult to define: e.g., transmission of knowledge or of know-how, broadening the mind, inculcation of attitudes, brain-training? It is all that and probably more. Even the link between inputs and this ill-defined output is not clear. The ability of teachers to teach does not seem to be connected in any specific way to their level of qualification. The complementarity between teaching aids and teachers means that the former's contribution cannot be easily identified. But there is also the fact that whereas production techniques for almost all goods have been altered radically by technical progress, educational services continue to be supplied by a production system based on skilled labour.

5. It was therefore tempting to try to replace teachers by machines in order to improve productivity in this sector of production. Unfortunately, the introduction of "modern educational facilities" has not always had the positive outcome that might have been hoped for. On the whole, the balance tends to be negative throughout the traditional education system. Should the possibility of modifying the "production function" of education therefore be abandoned? The spread of new information technologies (NIT) is currently raising high hopes, and many believe that discerning and widescale use of such technologies might this time enable most requirements to be met under highly satisfactory economic viability conditions. What is the truth of the matter?

6. This is the question this report will try to answer, first by reviewing the facts on educational costs and their recent trends, then showing the reasons why it is now essential to improve the economic effectiveness of educational systems, why "modern educational facilities" have not succeeded in doing so and why there is hope that, on the contrary, the introduction of NIT will. Two exploratory chapters will then review available information on NIT costs and efficiency (both internal and external), identify the remaining gaps that need to be filled to confirm the diagnosis and try to draw conclusions on the future of educational systems.

Chapter I

THE NECESSARY REFORM OF EDUCATION SYSTEMS

7. There are glaring inadequacies in the information available on education costs. An essential prerequisite for the comparative economic evaluation of different education systems is the rationalisation of concepts and more reliable statistics. Some discussion of the main problems and possible remedies are presented in annex (see Annex 1). Despite their limitations, however, the available data do reflect both the extent of public efforts in favour of education and the fact that a ceiling now seems to have been reached. Other observations seem to indicate a marked drop in the efficiency of traditional education systems and the virtual failure of modern efforts based on the media.

8. It is therefore necessary to look for other solutions. A number of factors seem to suggest that the large-scale use of new information technologies has a high potential efficiency.

A. TRENDS IN EDUCATION EXPENDITURE AND THE CONSEQUENCES THEREOF

9. Despite the inadequacies and gaps in the data, information on public expenditure on education is available for many countries and over a fairly long period. It is not so easy to study in detail changes in the breakdown of this expenditure, but a number of interesting pointers can be identified. Lastly, public efforts in favour of education and changes in them warrant study.

1. General Trends in Public Expenditure on Education

10. The time series available do not generally cover the whole of public expenditure, but only that by the central government (or regional authorities in decentralised countries) and not that by local authorities, or are even limited to expenditure by the Ministry of Education. Even for the developed countries, differences in coverage and definition mean that individual comparisons must be treated with caution. Despite a recent concertation and harmonisation effort between UNESCO and OECD, the series from the two sources still differ. Despite these limitations, the general trends can still be identified:

a) General Trends since 1960

11. These trends are meaningless unless expressed in constant currency terms. In spite of the conversion difficulties encountered, the main tendencies can be identified.

Table 1

TREND IN PUBLIC EXPENDITURE ON EDUCATION BETWEEN 1960 AND 1976 BY MAJOR REGION

REGIONS	Annual Average Growth Rate			
	1960-65	1965-70	1970-74	1974-76
Europe (excluding socialist countries)	+10.1	+4.3	+8.18	+4.57
Socialist countries in Europe			+6.55	+6.66
North America	+12.0	+7.9	+3.5	-1.3
Africa	+10.6	+9.1	+8.8	-10.1
Asia (excluding Japan)	+9.1	+7.6	+7.6	+25.7 (1)
Latin America	+13.1	+6.2	+9.4	+2.2
Developing countries	+10.8	+7.3	+8.5	+14.2 (2)
Developed countries	10.9	+6.4	+6.5	+2.3

(1) +11.2 excluding OPEC Member countries.
(2) +4,6 excluding OPEC Member countries.

Source: J.C. Eicher and F. Orivel: The allocation of educational resources in the world. UNESCO, Statistical Office, November 1979

The two most striking features are first the very rapid rate of increase in pulic expenditure on education at the beginning of the period and, second, the slower rate since 1970 and especially since the onset of the economic crisis (except in the oil producing countries).

b) Trends since 1970 in OECD countries (see Table 2)

12. On the whole, the recent growth rate is lower than it was. The effects of the crisis are clearly visible since expenditure decreased between 1974 and 1976 in four countries and rose only slightly in most others. However this

Table 2

RECENT TRENDS (1970-1979) IN EDUCATION EXPENDITURE IN OECD COUNTRIES
(in millions of 1976 $)

PAYS	Montant de la dépense				Tx croissance /an 1974-1979
	1970	1974	1976	1979	
Canada	11 696	12 301	14 176	11 882	-0.7
U.S.A.	92 730	106 916	102 033	119 325	+2.2
Japan	16 064	27 231	30 589	45 930	+11.1
Austria	1 459	2 113	2 391	3 001	+7.0
Belgium	2 242	4 007	3 941	6 286	+9.4
Denmark	2 011	2 939	3 044	3 036	+0.6
France	12 700	17 401	20 610	23 618	+6.3
Germany	13 816	20 998	23 146	26 902	+5.1
Greece	368	394	-	572	+7.7
Ireland	359	462	512	770	+7.5
Italy	6 794	9 809	9 267	9 438	-0.8
Luxemburg	90	121	-	205	+11.1
Netherlands	5 393	6 996	7 269	11 749	+9.2
Norway	1 337	1 953	2 425	2 578	+5.7
Portugal	160	334	585	21	-2.6
Sweden	4 665	5 148	5 715	7 221	+7.0
Switzerland	2 216	2 913	3 052	3 889	+5.9
United Kingdom	10 284	14 656	-	15 242	+0.8
Australia	2 905	5 310	5 427	6 276	+3.4
New Zealand	661	875	722	810	-1.5

Source: Author's calculations on the basis of UNESCO Statistical Yearbooks

reduction was merely temporary in most cases and expenditure began to rise again, although more slowly than before. There is a certain relationship between this trend and that of school demography which is characterised in most countries by reduced numbers of pupils in primary education and stabilisation in secondary. It would be mistaken, however, to conclude that continued low birth rates since 1975 should permit substantial reductions in educational expenditure during the 80s. The fact is that close study of the statistics and of policy measures shows that in most cases reduced pupil numbers have led to improved staff/pupil ratios, not to the standing down of a certain number of teachers, for their terms of employment usually protect them against redundancy.

2. Structure of Expenditure

13. It would be useful to have information on trends in the two main items likely to be directly influenced by the introduction of NIT, teachers' salaries and "teaching aids". Unfortunately the data available are incomplete and lacking in homogeneity. The data that seem to be the most reliable have been grouped below (see Table 3).

14. It can be seen immediately that teachers' salaries invariably form the largest item in the education budget (on average slightly more than two-thirds of current expenditure) in the countries observed. The table also shows that recently, the relative share of this item has increased in most countries (9 out of 14), the opposite trend being clear in only three countries, two of them Scandanavian (1). This confirms the previous observation, as salaries constitute the most difficult item to squeeze at a time of budget constraints, teachers usually being protected by powerful trade unions and by their public servant status.

3. Trends in the Public Educational Effort

a) Parameter selection problems

15. In order to understand the causes of the observed trends, it is important to know whether the latter are due to external constraints (or to changes in them) or whether they arise from a voluntary change in attitude towards education. Two parameters (others are possible) can be used to arrive at a diagnosis:

i) Cost per pupil, reflecting the quality of educational services; and

ii) The share of national resources used to finance education, reflecting the public educational effort.

b) Trend in Expenditure per Pupil

16. Since general trends embracing all levels of study would not make any sense, the following tables show series in constant currency for selected countries at primary and post-secondary levels. It may be noted that expenditure per pupil is invariably rising, often at a high rate. The same calculation for secondary education would not be very meaningful because of the differences between school systems and statistical definitions. However, spot checks show that the trends are fairly similar to those in primary education.

Table 3

TREND IN THE SHARE OF TEACHERS' SALARIES IN CURRENT PUBLIC EXPENDITURE ON EDUCATION IN WESTERN EUROPE (1975-1979)

PAYS	Teachers' salaries as a % total current expenditure		
	1975	1979	1980
Germany	71.9	72.4	-
Austria	48.1	49.5	53.1
Belgium	72.3	74.2	-
France	72.5	74.4	78.6
Greece	74.2	82.2	-
Ireland	70.4	66.0	67.6
Italy	73.4	68.2	-
Luxemburg	80.8	88.3	87.8
Norway	71.3	64.4 (1978)	49.1
Netherlands	75.5	74.1	73.5
Portugal	78.8	82.5	82.8
Sweden	52.4	44.4	46,5
Switzerland	61.5	61.7	61.0
United Kingdom	51.1 (1972)	50.2	-

Source: UNESCO Statistical Yearbook, 1983, table 4.2 and 1976 Yearbook, table 6.2.

Table 4

TREND IN PUBLIC EXPENDITURE ON PRIMARY EDUCATION PER PUPIL IN SELECTED OECD COUNTRIES (1965-1979)

COUNTRY	Total expenditure (1)		
	1965	1970	1979
Japan	58 096	84 082	132 408
France	808.8	1 181	1 316.2
Germany	943	1 276	2 584.6
Italy	201 458	156 700	191 333
Netherlands	928	940	1 613
Sweden	3 293	5 001	7 949
United Kingdom	89.5	83	143.9 (78)

(1) In 1970 monetary units.

Source: Author's calculations on the basis of the data in UNESCO yearbooks.

17. The same situation does not arise, however, in higher education, as shown in Table 5. At this level, there is a downward trend in expenditure in constant currency. In a few countries it started even before 1970, but became more or less generalised during the 1970s. This is chiefly due to the fact that staff/pupil ratios have deteriorated and, in most cases, general running expenditure (excluding salaries) has diminished in relative terms. There are therefore grounds to believe that the reduced expenditure is due mainly to a fall in the quality of education rather than to a rise in productivity with quality remaining constant.

c) Expenditure as a Percentage of GNP

18. Trends since 1960 by broad area, as in Table 6, show a sharp rise in expenditure during the 1960s but this was followed by a slowing down or reduction even in many developed countries since the early, and especially the mid-1970s. In Western Europe and North America expenditure on education has now levelled out and the most recent figures seem to confirm this new tendency. Examination of recent trends in a number of OECD countries, as shown in Annex 2, confirms this view.

Table 5

TRENDS IN PUBLIC EXPENDITURE ON POST-SECONDARY EDUCATION PER PUPIL ON A FEW OECD COUNTRIES (1965-1979)

COUNTRY	Total Expenditure (1)		
	1965	1970	1979
Canada	2 756	2 585	2 887
U.S.A.	2 046	2 302	-
Japan	516 300	630 811	546 192
France	6 091	7 704	4 517
Germany	5 953	6 354	4 579
Italy	362 369	400 048	280 895
Netherlands	12 293	12 886	9 113
Sweden	10 087	11 292	17 039
United Kingdom	871	844	741

(1) At 1970 prices.

Source: See Table 4.

B. IMPROVING EDUCATION EFFICIENCY -- PROBLEMS AND NEEDS

19. The figures show that the efficiency of traditional educational systems has considerably decreased. The efforts made to "modernise" education by introducing "modern educational facilities" have had very mixed and, on the whole, not very positive results. However, new information technologies seem to present a potentially efficient solution to at least some of the educational problems.

1. Growing Inefficiency of the Traditional System

20. Educational systems even today are characterised by the use of "production techniques" based on skilled labour, which have hardly changed for

Table 6

TRENDS IN PUBLIC EXPENDITURE ON EDUCATION AS A PERCENTAGE OF GNP SPENT ON EDUCATION (1960-1979)

REGIONS	Years					
	1960	1965	1970	1974	1976	1979
Developing countries	2.35	3.07	3.52	3.43	3.99	-
Developed countries	3.95	5.14	5.54	5.95	6.00	-
Western Europe	-	-	4.56	5.21	5.61	5.64
North America	3.9	5.4	6.5	6.4	6.2	6.5

Source: Eicher and Orivel, op. cit., updated by J. C. Eicher.

centuries. However their efficiency is increasingly called into question owing to:

i) The rise in the unit costs of education;

ii) The inability of education systems to meet all the objectives now set for them.

a) Rising Costs

21. Costs are high everywhere (see Section A). Several considerations suggest that this tendency is unlikely to be reversed:

i) The increase in requirements (extension of basic training and proliferation of adult training schemes) is leading to an equally rapid growth in total expenditure for a constant quality since, but for a few exceptions, there are no economies of scale because of the production techniques used;

ii) The concern to improve the quality of educational services and in particular the qualification level of teachers is increasing the cost per pupil;

iii) Less-developed countries are encouraged to bring the standards of their schools closer to those in more affluent countries;

iv) The protected status of teachers prohibits any major reduction in staff costs, whether in the form of salary cuts or an increase in educational duties.

22. There is no similar increase in the quality of education. The main reasons for this are as follows:

i) Following the intensive recruitment that prevailed everywhere between the mid-50s and the end of the 60s, the average age of teachers is rising and teaching staff costs are increasing automatically owing to promotions based on length of service, even in the absence of new recruitment;

ii) The pressure on the budget caused by automatic salary increases means in most cases that expenditure on teaching aids, on which education quality partly depends, has to be contained or even reduced;

iii) The considerable expansion in all educational systems has resulted in a more cumbersome administrative organisation and hence heavier administration costs, without leading to improved education.

b) Falling Efficiency

23. In some cases, this was the logical consequence of the lower quality of the educational services provided (see above). However, even where it has been possible to maintain or even improve quality, traditional systems have become less efficient because the situation has changed.

-- The traditional school is not suited to the transition from the training of the élite to mass education. The main reasons are uneven standards within classes, new pupil groups unable to adapt to classroom teaching, counter-productive allocation of teachers (inexperienced or less well-trained teachers being sent to rural areas and/or vocational streams, etc.);

-- The traditional school is increasingly competing with other sources of information and other training methods:

i) The media, especially television, transmit information and knowledge in a more attractive form competing with that supplied by the teacher, and are felt to be more interesting and more up-to-date;

ii) The specialised technological training supplied by technical education establishments is becoming more and more unsuited to the requirements of businesses using rapidly advancing technology.

23. At the request of the business world, large numbers of more independent, and therefore more flexible, specialised bodies have been created as they can tailor educational content to requirements more easily and apply new teaching techniques using more efficient aids.

-- New forms of demand have appeared.

24. The traditional school system was addressed to children and some adolescents. Nowadays, further categories of adolescents and, above all, different groups of adults are also demanding training:

-- Adolescents wishing to continue their studies nowadays often request vocation-oriented instruction within a less constricting framework than the traditional school;

-- More and more adults in active life are seeking to update their technical knowledge and/or to supplement their initial training without having to "go back to school";

-- More and more adults from a widening range of categories (housewives, pensioners, workers) are seeking to acquire information and training under flexible systems;

-- There is growing awareness that specific categories (the handicapped, the sick, children of immigrant workers, etc) are unable to fully benefit from education as supplied in traditional schools.

25. It is therefore necessary to find new solutions in order to meet new requirements satisfactorily, while remaining within an acceptable financial budget and improving the efficiency of education.

2. Relative Failure of the "Old" New Technologies

26. The problem of modernising education is by no means new. It was already realised over ten years ago that it would not be possible to provide universal basic schooling that would meet the requirements of the poorest countries without radical changes in the system. Attempts have already been made for over 20 years to renovate education in affluent countries by introducing modern equipment (radio, television, other audio-visual and/or audio-oral aids) at school and to experiment with the possibility of computer-assisted instruction. However, these experiments did not become general practice for the following reasons:

a) On the whole, the impact on costs was not positive

27. In traditional education:
In most cases, new equipment was supplied in addition to the traditional teaching aids, so costs went up. The experiments replacing teachers by machines (i.e. by replacing qualified teachers by assistants or by reducing the number of teacher-pupil contact hours so as to reduce the number of teachers) failed:

i) Effective use of such methods in fact requires highly qualified staff (e.g. TV primary education in the Ivory Coast);

ii) Administrative constraints and the bargaining strength of teacher's trade unions compared with the public authorities have generally prevented any direct or indirect replacement of men by machines.

Because the use of recorded programmes has not spread sufficiently the unit cost is still high.

28. Distance learning: One of the obvious advantages of the media is that

they make home study courses possible, in other words pupils do not have to assemble together at the same spot to listen to a lesson delivered by a teacher in front of them. This type of education is characterised by high fixed costs and low variable costs (compared with traditional education). Most design, production and transmission costs are fixed, i.e. independent of the number of pupils. On the other hand, the reception costs are to a large extent variable.

29. This has two implications:

i) The cost per pupil (or per contact-hour) diminishes with increasing numbers of pupils. The threshold beyond which this formula becomes competitive varies depending on the medium (or combination of media) used. Surveys show that radio broadcasting is the only method presenting guaranteed profitability (2);

ii) The cost may be partly transferred from central government to local authorities and/or pupils. This is particularly true in the case of reception costs (purchase of the receiver, cassettes, etc.).

b) The efficiency of the programmes actually implemented has seldom clearly exceeded that of traditional education

30. Internal efficiency: Evaluations of existing programmes do not systematically show better results than those obtained in traditional education. Close analysis of these trends shows that only programmes that have been the subject of long and well-planned preparation yield satisfactory results. In particular, the organisation and even the curriculum must not copy those of traditional education but must be tailored to the medium used.

31. The analysis also shows that where better results are obtained, they are at least partly due to greater motivation on the part of pupils rather than the intrinsic superiority of the programme. The efficiency of distance learning is very limited if minimal personal contact is not maintained between students and teachers and among students. This is due to the non-interactive nature of these media, which merely transmit a message.

32. External efficiency: Under the traditional system of education diplomas are issued which carry a certification power recognised both by the law and by employers. Distance learning cannot compete with traditional training unless its certification power is recognised, hence the problem of equivalence.

33. New types of public: Distance learning is sometimes the only possible way of supplying education to certain groups (such as highly scattered populations in remote areas, people working full-time, and persons physically unable to move for health reasons). In this case, comparison with the cost of traditional education becomes meaningless, but the technical methods used are possibly not, or no longer, the best possible.

3. Potential Efficiency of NIT

34. The semi-failure of "modern educational methods" can be explained by two factors:

i) They were often tacked on to a traditional system which was not ready to assimilate them, or an attempt was made to copy traditional school methods in home study programmes.

ii) They lack flexibility and interactivity. In order to simplify design and achieve savings, the system selected was usually based on a single medium. The message was heard and/or seen by the students in a passive manner. Even when it could be recorded to be reheard or reseen at the students' convenience, it was not possible to put questions directly to the author. In most cases it was necessary for a teacher to act as an intermediary but this might prove fruitless if the teacher had not designed the message himself.

Any improvement, diversification or adjustment of the system usually turned out to be very expensive. Potentially, new information technologies largely escape the second criticism and may prevent the first more easily than the previous generation of new education methods.

35. The supporters of NIT actually attribute three decisive (in their eyes) advantages to them:

i) They can improve the efficiency of the traditional school thanks to their interactive nature and the multiplier effect of using several media simultaneously;

ii) They can permit the provision of many types of training outside the framework of the traditional school, from home study aimed at a diploma or professional advancement to tailor-made self-teaching systems;

iii) They constitute a relatively inexpensive solution to present education problems.

36. It is therefore essential to examine more closely the available data on the costs and effectiveness of NIT to see whether, and under what conditions, in which fields and at what probable future date, they can in fact provide an economic solution to the problems of education.

Chapter II

THE COST OF NEW INFORMATION TECHNOLOGIES IN EDUCATION

37. Even if the introduction of NIT in education appears necessary in view of present technological trends and social changes, the fact remains that budgetary constraints prohibit the use of innovations which would involve substantial additional expenditure. This is why the supporters of these new technologies insist on the budgetary savings which, according to them, they should bring about and why governments are anxious to have reliable data on the financial consequences of deciding to introduce computers in schools on a large scale. Unfortunately, it is impossible to provide a precise evaluation of the cost of an educationl system based on NIT.

There are four reasons for this:

i) The hardware is not standardized and costs vary greatly from one type or country to another;

ii) The data available on direct costs are provided in a form which does not generally permit either economic interpretation or direct comparison with the cost of traditional education;

iii) It is well known that the costs of most of the components of media-based teaching systems are changing at rapid but unequal rates, so that extrapolation on the basis of available data is subject to a large margin of error;

iv) The costs induced by this structural upheaval have hardly been explored at all to date.

38. At this point it would therefore be futile and dangerous to try to provide an economic evaluation of costs and likely future trends. On the other hand, it is possible and useful to do two things, first, describe the methodology that should be used to measure costs and the problems encountered in obtaining figures and suggest ways of overcoming these problems and, second, take stock of existing data and show to what extent, if handled properly, they can provide some of the answers to the questions raised.

A. MEASURING COSTS -- METHODS AND PROBLEMS

39. The production function does not take at all the same form in a traditional education system as in one based on new technologies. In the first case, the essential factor of production is skilled labour, while in the second technological capital takes on great importance. This has three consequences for costs and their structure, and hence on their measurement. First, fixed costs are of much greater importance in the technology-based system so that the trend of total costs varies with the size of the system according to a law very different from that of the traditional system. Second, the breakdown of costs into their component parts has to take account of the different phases involved in the technology-based system. Third, the units of measurement cannot be the same as for traditional education.

40. The relationship between cost and budgetary expenditure is not the same in the new system as in the old. First, the opportunity costs are different and second, the adoption of a system based on modern technologies may involve a substantial shift of the cost burden from one group to another.

1. Form of the production function in an education system based on modern technologies and its impact on cost structure and trends

41. In the traditional education system the teacher occupies the central role, teaching aids account for only a small share of total budgetary cost and the duration of teacher-pupil contact is institutionally fixed as the same for all. The most important cost component to be analysed is therefore teacher salaries and the reference unit is the pupil.

This is not the case with a system based on NIT.

42. The consequences of the relative rise in fixed costs are as follows: The fact that most of the components of a system are acquired and paid for at a point in time and supply their services over several budgetary periods thereafter does not constitute a major problem. From the economic cost measurement standpoint it is easy to convert the purchase price into an annual rent over the lifetime of the equipment. From the standpoint of budgetary expenditure, all that is required is to stagger the introduction of new equipment and plan replacement purchases so as to avoid the "concertinating" of expenditure which would make the overall budget fluctuate drastically from one year to the next. The important point is that the costs of the different components of a technological system tend to vary less than proportionally to the number of pupils. This implies in fact that the comparative advantage of an NIT-based system with respect to a traditional one increases with size, so that there is little chance of there being any cost advantage as long as only small target populations are involved. It is therefore important to analyse in more detail the laws governing trends in the different cost components with respect to the size of the system. For this, however, it is first necessary to determine the most appropriate way of breaking down total cost.

43. There is need for a cost breakdown according to technical criteria. In the traditional system an economic classification with total, average and marginal costs, on the one hand and fixed, proportional variable and non-proportional variable costs on the other suffices because the factors of production used are relatively homogeneous. In the system based on NIT, the

fact that the system requires technological media between the sender of the educational message and the receiver means that the costs of the different stages through which the message passes before being received have to be examined.

44. A distinction can thus be made between:

i) The cost of designing and producing the message (i.e. getting it on to a machine-readable medium). This is a fixed cost in the sense that it remains the same regardless of the number of people receiving the message;

ii) The cost of transmission. The laws governing changes in this cost depend on the mode of transmission. If it is by an electromagnetic system (telephone line, radio or television broadcast), the cost is proportional to the time taken for the transmission, but does not vary according to the size of the audience;

iii) The cost of reception. Reception involves devices (television screen, computer memory, tape recorder, videorecorder, etc.) that can serve only a limited number of people. The cost therefore increases with the size of the audience, but stepwise and not proportionally.

45. The overall cost of an NIT-based system thus increases with the number of pupils, but less than proportionally, so that the cost per pupil tends to fall. But what interests us is the cost of supplying a given educational service, so that a lot depends on the time taken for the message to be assimilated.

46. New technologies have an impact on the time taken to transmit knowledge. In the traditional system, the duration of the different educational programmes is generally laid down for all establishments by regulations. The time for transmitting a given educational message is thus fixed in advance on the basis of experience of the efficiency of the traditional method of teaching through direct contact between an instructor and a group of pupils. The introduction of methods based on new technologies may enable this time to be reduced if, as claimed by the supporters of such systems, the student is able to assimilate the material more rapidly and requires shorter contact time with the teacher. In this case the economist is not interested in the annual cost per pupil but the cost of transmitting a programme. If it is desired to compare NIT-based programmes (provided that they are considered to take the same time to assimilate) the best unit of measurement is the pupil-hour. If it is desired to compare an NTI based with a traditional system the most suitable unit is the cost of the programme per pupil.

2. Cost, Expenditure and Financing

47. As was seen in Chapter I, budgetary expenditure is not to be equated with cost as the latter has to include the opportunity cost which has to be added to that of the resources used. This distinction is particularly important in the case of a system based on new technologies. It is also

important to determine who has to bear these costs, since those who pay are not exactly the same in the two systems.

48. There are differences in cost between the two systems. Education economists have often pointed out that a substantial share of the cost of studies from the standpoint of the individual is foregone earnings. This is particularly true in the case of courses for adults when they are held during normal working hours. It has in fact been calculated that in a "traditional" cycle this could account for over 95 per cent of the total cost. To the extent that the use of new technologies may on the one hand enable the total training period to be considerably reduced and on the other, thanks to its flexibility, enable the training to be organised mainly outside working hours, there should be a very marked reduction in the total cost of the training cycle. However, the second factor may very well merely bring about a shift of cost from the employer to the employee, if the traditional cycle was at the employer's expense and the employee cannot persuade him to maintain this arrangement. As regards basic schooling on the other hand it is unlikely that the large-scale introduction of NIT in schools will reduce the duration of educational cycles. But if the effect of the current technological revolution on working time and job supplied is considered, it may be assumed that on the one hand the foregone earnings of school-leavers will be reduced because they are more employable and on the other that the new organisation will enable vocational training to be obtained at the same time as a formal educational qualification, which again should facilitate subsequent insertion in the labour market.

49. There may be several possible effects on the different payers. The public education system at present dominates in a majority of countries and is financed to a very large extent through government sources. Financing the technical equipment required by the new system may bring about a partial shift of the budgetary burden to three other payer groups:

i) In countries where financing is centralised it can already be seen that governments are tending to encourage local authorities to contribute to the purchase of equipment for schools within their areas;

ii) The use of micro-computers and video recorders by pupils encourages the private purchase of such machines by parents and later on by young adults who recognised the value of them during their studies, so that private manufacturers are generally prepared to supply educational establilshments at a reduced price. This practice is at present common in most Western industrialised countries;

iii) When such equipment is used in the context of distance learning, the cost is usually borne by the "pupil".

50. It is thus possible that in the future part of the financial burden of education will gradually shift from governments to other groups, and in particular to households. This insidious fashion of modifying the responsibilities of the state raises a number of problems. In order to make an accurate evaluation of the economic costs entailed in the large-scale use of new information technologies and calculate the total cost of education organised in this way it is essential to have reliable data presented in a

standardized way. Even if financial flows only are considered, it is essential to:

i) Calculate the budgetary cost per pupil of a clearly defined course or programme;

ii) Compare and monitor over a period the cost of different items of equipment valued at constant prices;

iii) Breakdown the total cost of technical equipment according to the phase of the knowledge transmission process;

iv) Identify the share of the total cost imputed to each payer.

These conditions are far from fulfilled at present, so that it is hazardous to try to draw general conclusions. It is neverthless possible to present a partial and approximate picture of the situation and (with due caution) indicate probable future trends on the basis of the available information.

B. DATA ON COSTS -- INFORMATION CONTENT AND SHORTCOMINGS

51. It is impossible to make any valid critical assessment of the available figures concerning the total cost of modern technology-based education without prior examination of first, the available data on the different components of this cost and, second, the way these data were derived and presented. We shall therefore first review the cost evaluations of the different phases of providing individual customers with the "educational message" and the medium-term future projections of these costs. Only then will we proceed to a critical examination of total cost and try to establish whether it is possible to determine reliable unit costs.

1. Cost of the Different Phases of Transmitting the "Educational Message"

52. Taking the distinction made in the first part of this chapter between the production, transmission proper and reception phases, we shall examine in each case the existing data available on the component parts of the technical system used and discuss their reliability, passing from evaluations based on observed reality to forward studies of anticipated future trends. It must not be forgotten, however, that new technologies will not totally or immediately replace traditional inputs, in particular teachers. In a second stage we shall therefore try to assess the impact of the introduction of NIT on these traditional components of education costs.

53. The cost of new technologies:
The phase of producing the "educational message" can theoretically be broken down into two stages, the development of an educational programme and its reproduction on a storage medium, generally for use with a computer. In practice it is difficult to disassociate the two stages because the constraints imposed by the medium determine not only the form but also, at least to some extent, the content of the message. We shall thus examine the cost of producing educational software.

54. The costs are mainly wage costs. It is in fact generally agreed that the production of efficient educational software requires the participation of a fairly considerable number of people with different skills:

i) At the programme production stage, an author is responsible for the design and for writing accompanying texts; an education expert puts the work into appropriate form; a programmer codes the material according to the instructions of the first two; a graphics expert is responsible for graphics, layout and presentation; lastly a marketing expert studies the potential market and adaptation of the product to the market. The time spent by the first two persons (or groups) can be evaluated fairly accurately, but this is not true of the others, as everything depends on the general design of the programme. Similarly, wages vary with the supply and demand situation. It can be assumed that programmers' wages will be high because they are at present scarce on the market;

ii) At the reproduction stage it is necessary to distinguish between the cost of copying discs or tapes, that of printing the documents, texts and instructions and that of preparing a model packing and reproducing it. The cost varies with the length of the documents and the number of copies required.

55. Evaluations of total cost are few and far between. What is more, it is difficult to compare them because they do not use the same reference unit. One United States estimate indicates a minimum of $100 000 (of which $30 000 for the designers' wages) for the design and production of a one-semester course, a cost which could reach $150 000 if interactive video discs were used. Another United States estimate (3) indicates that we have to reckon with $15 000 per course unit and each teacher needs 100 units per year, which seems to indicate a cost of $750 000 per semester. A French study (4) gives a figure of FF 50 000 to FF 200 000 per hour of CAI. If a semester course is asumed to represent 60 to 100 hours of instruction, the price ranges from FF 3 to FF 20 million or between $2.5 million per course. It is thus difficult to draw any precise conclusions from figures that apper to be not strictly comparable. In any event, however, while these sums appear very high, the unit cost is in fact very low if the same course is given to hundreds of thousands of pupils and can be used for several years. Likely future cost trends are even more difficult to determine. It is nevertheless likely that the costs indicated above will not change very much since we are concerned with evaluating the cost of a high quality software package and not with measuring the cost of existing packages. Wage costs will probably tend to increase and the scope for reducing technical production costs will be fairly limited. If there is to be any significant change as compared with educational software at present in use, it is more likely to take the form of improved quality -- this being still very mediocre in most cases (cf. Chapter III) -- than that of a reduction in unit cost.

56. The transmission phase is that in which the educational message travels from the place where it was produced to that where it is received. Evaluating the cost here, evan approximately, is even more problematical than in the production phase because it varies enormously according to the type of transmission, which in turn depends on the technology used and its level of development. In order to throw more light on the question a distinction can be

made between on the one hand the transmission of a computer programme and on the other that of audio-visual documents. In both cases two extreme solutions are conceivable. If the computer programme and accompanying instructions have to be transmitted from a central computer to a terminal via a telephone line the cost depends on the time of transmission and can be very high. If it is desired that the programme be truly interactive, i.e. that the pupil be able to communicate with the machine in real time, it is necessary first to occupy a telephone line during the whole duration of the "lesson" and second to pay at the highest rate because teaching usually takes place during normal working hours (5).

57. The estimates range from about $1 300 per hour for a teleconference with ten participants scattered over the five continents to about $15 for the vidionet system in the Netherlands and $6 to $12 for the Plato system. Future trends will depend on telecommunications costs which are not likely to fall in the near future but could drop substantially in the longer term, especially if, as may be expected, preferential rates are granted for education. If, on the other hand, the programme can be run locally from a disc, the transmission cost is limited to that of sending the disc and is thus negligible when divided by the number of students. The same is true for the transmission of audio-visual documents. If these have to be broadcast the cost is that of using the transmitter for the duration of the lesson. A Dutch study puts this at $1 340 per hour. If the programme has been recorded on video-disc, the transmission cost is again negligible except in the case of a single student, but even in this latter case is still relatively low. There is not likely to be any major change in this cost component which in any case is very low per pupil.

58. The reception phase is that in which the message is decoded and presented to the pupil. The cost is mainly that of the equipment. Modern education systems using new information technologies are based on the computer. At the present stage two types of organisation coexist. First, a mini-computer with terminals and second, micro-computers each serving a group of pupils and possibly being able to communicate with one another. This distinction is likely to become irrelevant in the near future because of constant improvements in micro-computers which can already perform the functions of minis. We shall therefore consider only cost studies dealing with micro-computers.

59. This is the field in which the data are most plentiful, most reliable and most consistent. According to the type of hardware, the cost ranges from a minimum of $300 to a maximum of $6 000, with an average price for a machine with the generally accepted minimum level of performance costing between $1 000 and $2 000. It is generally considered that this cost, which has halved every two years since such equipment first appeared, will continue to do so for at least another four years. Certain authors even expect a cost of $100 in 1990 (6). More detailed studies, such as that by Jacob Schwartz (7) put the 1990 price at $300, but this is because they consider that the production cost has to be multiplied by at least three to obtain the selling price.

60. An analysis of the different components making up the price of a micro-computer, however, shows that these forecasts may be over-optimistic. The price can in fact be broken down into three roughly equal parts (8):

i) Technical manufacturing costs plus the manufacturers profit. The integrated circuits (central processor and memory) probably account for less than 10 per cent of this item, while the disc storage accounts for 30 per cent, assembly 10 to 15 per cent and ancillary equipment (power supply, chassis and housing, keyboard) 20 to 30 per cent. As labour accounts for a substantial share of the cost of these last components and opportunities for technical improvement seem more limited than is the case with integrated circuits, the conclusion must be that the scope for further cost reductions diminishes as the relative share of integrated circuits falls;

ii) Development costs in the broad sense (R & D, marketing and promotion) plus overheads. The prospect of any reduction here is even more remote than for the first category;

iii) Marketing costs, including the retailer's profit. With the expansion of the market and increased competition between producers these costs may fall a little, but certainly not much. It is nevertheless possible that for the sales promotion reasons mentioned above this cost may be low or zero for education establishments.

61. There are thus grounds to believe that the scope for further reductions in micro-computer prices is being exhausted and prices are closer to levelling off than is thought by the authors of the above-mentioned studies. This view is supported by another observation. Price trend forecasts are based on a given type of equipment and marketing organisation. The fact is, however, that when a new, more powerful model is launched on the market the earlier one is soon withdrawn from sale. The trend is thus not so much towards a reduction in the price of equipment with more or less stable performance but more in the direction of significantly improved performance at a more or less constant price. An improved cost/effectiveness ratio is thus much more likely that an abortive reduction in cost (9).

62. The hardware does not consist of the central processor only. Other major components are:

i) Fast memory: present cost is estimated at $1 000 per megabyte and is expected to fall considerably by 1990 (10) but it is also considered desirable that capacity should be increased to eight megabytes which would keep the cost at about $2 000 while multiplying capacity by four and thus permitting very high quality graphic reproduction and considerably simplified programming.

ii) Mass storage (slow memory) enables a great quantity of information to be stored and used as required. Prices per unit capacity are likely to fall substantially, but this will probably result in a dramatic increase in capacity for slightly lower cost;

iii) Reader costs at present vary according to type of storage (tape cassette or floppy disc), but the advantages of the floppy are such that tapes are likely to drop out of use. The use of a floppy disc unit is at present estimated at about $1 000 and that of a much improved version at $500 by 1990;

iv) Display screen: currently estimated at $4[illegible] $600 the price is not expected to fall much by 1990;

v) Other hardware: this concerns audio-output devices, especially of language emitted by the machine, interfaces, etc. No significant price falls are expected. J. Schwartz puts the cost of a standard facility at $550 by 1990.

63. All this hardware requires maintenance and repair however. The maintenance cost for "traditional" equipment (computers, language laboratories, etc.) is already high. As regards the different components of the new integrated systems, it seems that maintenance will continue to be an important cost item. According to a French source (11), maintenance costs already exceed the cost of hardware depreciation and are likely to increase, at least relatively, in the future. A United States evaluation of the Plato system, although lumping software and maintenance costs together, seems to arrive at a comparable figure (12). These costs could be significantly reduced if manufacturers were willing to alter equipment design so that servicing is reduced to tasks of low technical content that could be carried out by the user (changing cards or modules) (13). Such a development appears unlikely, however, because of the vested interests of repairers on the one hand and manufacturers on the other, the latter preferring to be able to offer cheaper equipment in the hope that users will not hesitate to replace it in the case of breakdown.

64. The overall cost trend for these new technologies is thus a downward one, though this is much less marked when all the different components are examined separately than when attention is concentrated on the central processor. But these technical resources will not, in most cases, replace the traditional inputs and especially teachers. As these latter account for by far the greater part of the cost of traditional education it is essential to try to forecast the likely future trend here.

65. The introduction of new technologies will have an impact on wage costs. The production and maintenance of the hardware making up the new technical systems used in education gives rise to significant wage costs. As seen above, in every case where wages account for a significant share of the cost of a component, no significant price fall is to be expected. This is particularly true of maintenance but can also be seen in the mechanical parts of the hardware and in assembly. Secondly, using NIT generally leads to the recruitment of new staff -- technicians, programmers -- who usually receive fairly high wages, the cost of which is virtually never included in new technology cost evaluations. It is therefore essential to take account of this item which is very likely to significantly increase total cost and reduce its tendency to fall over time. Lastly, and above all, in most cases the machines do not completely replace teachers.

66. In the traditional school no significant fall in wage costs is to be expected. On the contrary, there are indications of an upward trend. As seen above, a number of technicians are recruited alongside the teachers in schools where NIT are introduced on a large scale. The teachers themselves need substantial retraining before they can make effective use of these technical resources. This retraining has to be on a large scale and the cost is very high. In 1983-84, for example, the French Government spent FF 200 million on training 20 000 teachers, which represents FF 10,000 or $1 250 per teacher.

What is more, wherever the teachers are defended by strong unions it can be expected that the latter will claim wage increases to reward the increased level of qualification. Lastly, contrary to what is commonly claimed, the need for teachers is actually likely to increase. The hypothesis generally put forward is that in the new system the pupils spend part of their time with the machine in small groups and do not need the teacher's constant supervision. The teacher should not only be able to free himself from the least interesting tasks (see Chapter III) but can also look after a bigger number of pupils. Staff-pupil ratios could therefore fall, and with them wage costs. This optimistic assessment, however, needs to be tempered at least in the short term by the following considerations:

i) First, in most countries teachers are covered by a contract that protects them against redundancy. The only way of reducing numbers would thus be a lower rate of recruitment or even non-replacement of teachers retiring or leaving the profession for other reasons (resignation, death, etc.). The effects would be felt only very gradually even in the best of cases -- if the education system were expended rapidly. The effect is likely to be minimal in a period of falling student numbers;

ii) Second, teacher's claims for improved staff-pupil ratios are strong enough for the authorities (or elected bodies administering schools) to be reluctant to take any measures appearing to go in the opposite direction;

iii) Third, the new technologies require pupils to work in small groups. As long as the optimum level of equipment has not been reached in schools the time each pupils spends with the machine will remain short and the scope for economies will be limited. Even in fully equipped establishments, scarcely any more than half an hour of individual contact per day is planned, so that the pupil is in contact with the teacher for by far the greater part of the time.

iv) What is more, working in small groups can in certain cases necessitate much higher staff-pupil ratios. This is particularly true at primary level, where pupils need constant supervision, and in higher education, at least in those countries and disciplines where most of the teaching was formerly done by lecturing to large numbers of students. Where one lecturer could give a course to two or three hundred students, four or five times as many will be needed to supervise one hundred groups of three.

67. If care is not taken, the large scale introduction of NIT in education is thus likely to substantially increase total costs in the next few years, mainly because of higher wage costs. This is obviously not the case with distance learning, in particular adult training, where wage costs can be reduced considerably by completely doing away with a tutor. Even in traditional education, it is likely in the longer term that the presence of the new equipment and pressure by pupils will oblige the system and those in charge of it to reorganise fairly drastically and this could result in significant wage cost reductions. At present, however, nobody can forecast how long it will be before such an effect comes about or how far it will go. On this basis is it possible to measure the total cost of a system using NIT

and compare it with the cost of a traditional education system?

2. Total Cost Calculation and Comparison -- Problems and Limitations

68. First of all, it is worthwhile giving an idea of the size of the investment involved by examining the rate of introduction of new equipment into the school system. We shall then take the example of one of the rare systematic and reasoned evaluations available to show the degree of uncertainty that still remains in this field. Lastly, we shall try to see whether it is possible to make a comparison with the cost of traditional education.

69. The investment effort is considerable, as can be seen from a few figures. The average annual increase in the number of microcomputers in education establishments between 1979 and 1983 was:

-- 89 per cent in France;

-- 74 per cent in Germany;

-- 58 per cent in the United Kingdom;

-- 49 per cent in the Scandinavian countries;

-- 61 per cent in the other West European countries;

-- 42 per cent in the United States;

In this last country 325 000 microcomputers (14) were installed in schools during 1983, 14 6000 in Germany, 9 400 in the United Kingdom, 7 600 in France (where there should be 32 000 by 31st December 1984), 400 in Italy, 4 400 in the Scandinavian countries and 6 900 in the rest of Western Europe. A similar effort (though varying from one country to another and unequally distributed as regards level of education) is found in all OECD Member countries (15).

70. This effort should be maintained in the years to come. France, for example, plans to have 100 000 micros installed by 1988 and a US study gives a figure of 1 250 000 for the United States. Despite this effort, however, the level of equipment is still far from the minimum required for the efficient use of these new technologies. In the United States, the leading country in this field, 62 per cent of elementary schools have been equipped, but the majority of them have only one microcomputer. At secondary level, 83 per cent of the establishments have at least one micro but the proportion that can allow all their pupils to use the machine for at least a quarter of an hour a day is very low. In order for each pupil to have 20 minutes machine contact a day, which appears to be the minimum to be any use, A. Melmed (16) has calculated that 2 500 000 microcomputers would be required. In order to reach this figure by the end of the decade the rate of acquisition would have to be doubled during a further two years (it has already increased by a factor of six in three years) and subsequently be maintained at a level of 500 000 a year, i.e. over twice the present stock. In the case of France, the installed stock at the end of 1983 was 11 000 machines and the figure is planned to rise to 100 000 by 1988. For each pupil to have 20 minutes contact per day over 600 000 would be required. These overall figures concern only the computer

part of the essential integrated system. The stock of peripherals (high definition screens, videodisk readers, fast memories, etc.) is even more inadequate and, as we have seen, improving the equipment rate will increase costs much more than micros. Furthermore, some of the computer equipment now installed is totally inadequate for the tasks required of NIT and will have to be replaced by more powerful hardware. A considerable effort has therefore been made but it needs to be maintained for at least five to ten years, depending on the country, in order to reach the critical mass.

71. Problems are encountered in the evaluation of total cost. It is pointless to try to present the different evaluation studies available as they concern situations that are too different, use methodologies that diverge too much and have degrees of coverage too unequal for any valid conclusions to be drawn. On the other hand it is possible to derive some interesting pointers from a critical examination of an evaluation carried out with the necessary minimum level of rigour and exhaustiveness. The example taken is that already mentioned of Arthur Melmed for the United States (17). As the average cost of a microcomputer is estimated at $1 000, the rise in equipment indicated by the author would involve an expenditure reaching a ceiling of $500 million a year at the end of the decade.

72. At the same time, expenditure on software and courseware should increase to between $100 and $200 million a year. Details of the calculation are as follows: In order to be in contact with the machine for 20 minutes a day throughout the twelve years of primary and secondary schooling, a pupil needs 720 hours of educational software. But since pupils' needs are not the same in different subjects, this figure needs to be multiplied by a factor of 4 to 6 which gives a total of 3 000 to 4 000 hours of software per pupil. If the average cost of production of one hour of software is estimated at $30 000 and its average life at 5 years, the average annual cost is between $90 and 120 million. Taking account of the rapidly changing needs and rising minimum acceptable standards, it can be assumed that the average life of courseware is likely to fall to 2 1/2 years, which would bring the average annual cost up to something like $200 million (18). A. Melmed's conclusion is striking -- if this total expenditure of $600 to $700 million is compared with the total primary and secondary education budget of $140 billion, it can be seen that the large scale introduction of NIT's would increase this budget by only about 0.5 per cent. Even if the margin of error in this evaluation of total cost was as much as 50 per cent, the total increase would not be more than 1 per cent. For purposes of comparison, an average 3 per cent increase in teachers' wages would represent a comparable percentage increase in the total budget.

73. This evaluation raises several types of problems:

i) While showing that the cost of new technologies is almost negligible compared with the total budget, it seems to conclude that no savings are to be expected in other budget items so that total cost will increase, although only very slightly, with the introduction of NIT;

ii) The cost evaluations presented are open to criticism. According to the degree of optimism or pessimism with regard to future microcomputer unit cost trends and minimum acceptable performance levels, the forecast unit price for the end of the decade ranges from $100 to $2 000. For the reasons explained above, we are

personally inclined to expect a figure of between $1 000 and $2 000, hence higher than Melmed's. The evaluation of software costs is open to similar criticism. According to the assumptions the estimate can range from half Melmed's figure to three or four times as much;

iii) The evaluation is very fragmentary. It does not appear to take account of any hardware except the basic mircocomputer. If peripheral storage, readers, interfaces, etc. are added, the hardware cost is easily multiplied by four. It does not specifically include maintenance costs which are high and are not likely to evolve in a favourable direction. Lastly, it does not take account of the possible need for improved staff-pupil ratios caused by the introduction of NIT. If this is the case, A. Melmed's demonstration, in drawing attention to the dominant role of wage costs, leads to the expectatio of a much more marked increase in total cost.

74. In considering the possibility of comparing an NIT based system with a traditional education system, a distinction has to be made between two cases. First, the introduction of NIT in teacning establishments to help with basic education. Second, the use of NIT to provide training for groups who, for various reasons, are not able or willing to attend traditional establishments. In the first case (at least in the short and medium term) no radical changes are to be expected in programmes or the organisation of teaching. This means in the first place that the duration of education cycles is scarcely likely to be changed. It also means that even in the best of cases the number of teachers can fall only very slightly and very gradually. There are in fact very strong pressures for the improvement of staff-pupil ratios, especially at primary and higher education levels, and also for increased teacher salaries. The cost of hardware is impossible to estimate without a very large margin of error, but it is clear that at most it is likely to represent only a few per cent of the total education budget.

75. All in all, it is more logical to expect an increase in total cost over the next few years rather than decrease, but this will depend on policy with respect to staffing, target equipment levels and hardware utilisation times. In the case of distance learning on the other hand, the cost can be much lower than in the case of comparable traditional education because this method of teaching allows wage costs to be cut very substantially. If it is wished to improve our knowledge of this field where much remains to be desired, more in-depth cost studies are required, with standardization of methods and reference units, together with longitudinal studies of experiments at present under way.

Chapter III

THE EFFICIENCY OF NEW INFORMATION TECHNOLOGIES IN EDUCATION

76. Many people, like the members of the Carnegie Commission, hold that the application of modern technology constitutes the fourth revolution in the field of education, after the appearance of the school, of written material and of printing. This view is based on the conviction that the use of these technical resources makes it possible to do what was already done in the schools much better, and to do much more, and that this will be even truer in the near future. This enthusiasm, however, is based to a large extent on a rosy view of the future. There is in fact a big gap between the progress hoped for from the use of NIT and that already recorded and objectively measured. This gap is partly due to the fact that information technologies are evolving very rapidly and their present potential is far from being fully exploited, but part of the problem is also that the supporters of NIT tend to have an over-optimistic view of their practical effectiveness in the face of institutional and human constraints. Lastly, some potentially negative effects of this technological revolution generally tend to be passed over in silence or minimised.

77. It is therefore necessary on the one hand to examine the established facts as determined by the evaluations so far carried out, and on the other to logically discuss assertions which have not yet been tested, either because the applications concerned are too recent or because they have not yet been implemented. It is also necessary, however, to try to throw light on some effects that have so far been discussed little if at all, particularly as regards the external efficiency of NIT-based education systems. This section reviews in turn improvements in the efficiency of traditional school tasks, the possible extension of these functions, and the external effects.

Section 1:

INCREASING THE EFFICIENCY OF THE TRADITIONAL EDUCATION SYSTEM

78. The advantages claimed for the introduction of NIT in schools have been more or less well documented by evaluation studies and the findings are more or less in line with the claims.

A. THE SUPPOSED ADVANTAGES OF NIT

79. These advantages concern first of all pupils, who are supposed to have improved acquisition rates and more positive attitudes. They also concern teachers, whose role is made more interesting while the task of evaluation is made easier. Lastly, they also concern the management of educational establishments.

1. The learning process is facilitated and accelerated

80. The interactive nature of the system allows each pupil not only to correct his errors but to understand why he made them. A new point in the programme is not introduced until the preceding one has been assimilated. At the same time, this enables each pupil to proceed at his own rate and thus not suffer from the slowness of others if he learns quickly and not to hold up the class if he has problems. By forcing the pupil to concentrate his attention, the machine encourages faster learning than the traditional class, thus, in the final analysis, allowing both the acquisition of more knowledge and more free time in a given period. Lastly, the logic and precision of the language that has to be used with the machine means that a certain discipline has to be developed in the presentation of ideas and the formulation of questions and answers and the faculty of abstraction is improved.

2. The pupil's interest in school is increased

81. Most teachers complain about the general drop in the pupil's level of interest in lessons. This is frequently attributed on the one hand to competition from the media, which offer a great deal of information competing with that the teacher is supposed to impart and present it in a more agreable way, and on the other to increasing heterogeneity of classes resulting from the democratisation of education, which constitutes a handicap for the pupils coming from cultural environments furthest away from that of the school, who get discouraged, especially if they are shy and are afraid of asking for explanations. An interactive computerised system in the first place enables those who have difficulty in expressing themselves in writing or orally to get over their problem since the machine does not ridicule or reprimand, but simply corrects. It enables the shyest to express themselves and the cleverest to demonstrate their talent. It also enables pupils to get involved in school work thanks to some of the exercises being like games, thanks to the abundance of information the machine can provide very quickly and, lastly, thanks to many pupils making it a point of honour to master the machine and get the better of it.

3. Teachers' assessment tasks are eased

82. Correcting exercises is a tedious task and takes up a lot of time. The same is true of recording marks and overall school performance. Using computer methods means that at least some of the exercises can be corrected and a fair copy supplied by the machine. It also means that the whole of a pupil's marks since he started school can be stored and makes it very easy to calculate class averages and the dispersion of marks, compare different

classses, etc. Analysing results in this way may in turn enable anomalies to be detected and corrected.

4. The teacher can devote hmself entirely to "noble" tasks

83. The machine can easily replace the teacher for repetitive and boring tasks such as the dictating of exercises, words or symbols to be memorised and checking that they have in fact been learnt. It enables part of the class to be occupied, giving the teacher more possibilities for individual contact, so that he can help pupils develop their reasoning powers, adjust his teaching methods according to individual problems and shortcomings, etc. It also enables the teacher to vary the centres of interest and stimulate pupils' desire to learn by calling on more varied sources of documentation and letting them do additional exercises when it suits them.

5. The management of teaching establishments is facilitated

84. The computer's information storage and processing capabilities permit not only the management of examinations and marks but also student records and the establishment of timetables, jobs that normally not only take up a lot of teachers' time but are also not always very efficiently performed by these people who are not trained for such tasks. The advantages expected here are obviously considerable. It is necessary, however, on the one hand to check that they actually exist in specific situations, and on the other hand to be aware of the conditions that have to be met for them to materialise.

B. THE FINDINGS OF EVALUATION STUDIES

85. Evaluation studies have been mainly concerned with knowledge acquisition, this being the easiest thing to measure. Information is also available, however, on pupil attitudes and, though much more rarely, teacher reactions.

1. The effect of new technologies on knowledge acquisition

86. Most evaluation studies have been carried out in the United States, partly because there is already a certain amount of experience in this country and partly because the attitude of innovators is more favourable to external evaluation. Most studies are concerned with computer-assisted instruction. The findings are very much in agreement, despite the sometimes substantial differences in the magnitude of the observed effects. They show:

i) Improved results, particularly in scientific disciplines. The average improvement recorded in mathematics, for example, is of 0.4 standard deviation at primary level and 0.3 at secondary level, but only 0.1 in first cycle tertiary (19). Evaluations by comparison with control groups (20) have shown progress in mathematics by primary pupils of the average level of the control group in the 64th percentile of this group at the end of one year,

in the 71st after two years and in the 76th after three years. These effects were even more marked if specific tests for each course were used instead of standardized tests. There also seems to be positive effects in reading, spelling, grammar and drafting, but they are not so clearcut and, above all, they hardly seem to continue after the first year (21);

ii) A substantial increase in the speed of acquisition. The time saved is considerable in all subject areas, the recorded results ranging from 33 to 80 per cent;

iii) There is a very marked difference according to whether the computer completely replaces traditional teaching or is used in a classroom situation. The positive effects seem to be much less apparent in the first case. A Norwegian study (22) confirms the findings of some United States studies cited by S. Hartley (23);

iv) The positive effects are probably greater for recent than for older experiments, which would appear to indicate, according to J.K. Kulik and R.L. Bangert-Drowns, that teachers have learnt how to make better use of computer methods.

2. The effects on reasoning powers

87. This is more difficult to evaluate objectively than is the acquisition of knowledge. The studies are therefore far fewer and much more qualitative in nature. They nevertheless still indicate a positive effect especially as regards ability to solve algebra problems.

3. The effect on pupil attitudes

88. Here again evaluation studies are relatively few and far between. Some conclude that attitudes towards school are improved by the introduction of computers, but not very much (24), while others find a very positive effect on pupil interest, attendance rates and even the respect of premises (significant reduction in vandalism) (25). An experiment with young delinquents even indicated that the computer was the only way of stimulating interest in these young people, normally allergic to school, and making them take up their studies again. What is more, all studies show a marked increase in interest in computers and their applications after an initial contact with the machine, a factor considered very positive in a world where computers are bound to occupy an increasingly important place.

4. The effect on teachers

89. Some observers have pointed out that the majority of teachers do not participate in the development of programs and feel somewhat removed from the teaching and not really in control of it. The conclusion is that this represents a potential obstacle to the universal use of NIT in schools.

90. The findings of these studies are thus nevertheless generally positive and sometimes even very positive. But it must not be forgotten that, as

rightly pointed out by Ludwig Braun, "a substantial share of the technologies used have not been examined in depth; some have not even been evaluated at all. Even as regards the computer which has been used experimentally as a teaching tool for about two decades, the majority of the most interesting applications have been developed only very recently and have not been subjected even to preliminary evaluation" (26). It is thus difficult and even dangerous to use the evaluation of past experiments as a basis for assessing the present and above all future possibilities for NIT in education.

Section 2:

THE EXTENSION OF EDUCATIONAL ACTIVITIES THANKS TO NIT

91. Here there has to be much more reliance on innovators' claims because there are still virtually no evaluations. An attempt can nevertheless be made to identify the conditions that have to be fulfilled for these claims to become reality.

A. POTENTIAL ADVANTAGES OF NIT

92. Some applications are simple extensions of traditional activities, while others represent major innovations enabling teachers to do what was previously impossible within the budgetary constraints imposed.

1. NIT can substantially enrich traditional teaching

93. To the extent that an integrated IT system allows access to all available data banks and numerous audiovisual documents, the teaching of subjects like history, geography, natural sciences and even the physical sciences and literature, can be enriched and pluri and interdisciplinary approaches can be developed. It makes the teacher's job at once easier and more interesting, enabling him to always have up-to-date material and to choose among numercus illustrative documents. It also makes it possible to use the educational potential of broadcast television programmes by showing in class those that appear useful, enabling the pupils to understand them better and to comment on them. More fundamentally, access to these new tools indirectly causes a renewal of traditional teaching through breaking down barriers between disciplines and allowing teaching by goals (27). These powerful teaching aids also enable teachers to multiply teaching strategies, even more than does the computer alone. The use of educational games and simulations has already become fairly common. At class group level it is possible to compare theoretical models with real experience, give a better understanding of abstract concepts, etc. The teaching of writing can be enlivened by using word processors. The teaching can also be adapted to the needs of each pupil through forming small groups whose membership changes with the subject in order to take account of the strengths and weaknesses of each member. On the basis of his observations the teacher can much more easily adapt his methods to the reality of his class. He will also have access to

increasing numbers of models developed by researchers exploring the new possibilities offered by NIT.

94. Lastly, thanks to the large volume of information that can be stored on pupils and in particular their individual rates of assimilation and progress, these systems allow teachers to better identify the problems encountered and take appropriate remedial action. Through a feedback process this information should also enable the authors of interactive educational software to make improvements and compare the advantages and disadvantages of each method. New information technologies should therefore in principle greatly improve the efficiency and interest of traditional teaching, but they should also permit completely new methods.

2. NIT allow the development of teaching hitherto impossible

95. Thanks to the virtually infinite simulation possibilities offered by these integrated technological systems it is possible to represent and explain phenomena that cannot be handled directly. This is obvious for dangerous phenomena such as the internal operation of a nuclear reactor or when it is a matter of observing phenomena which actually occupy a time much too short or too long to allow direct observation. But this capability is also used in practice to economise on very costly experiments. The example of flight simulators and the considerable sums saved by airlines and air forces in pilot training is the best known, but is far from being the only one.

96. This new teaching may take place inside or outside the traditional school and, more generally, NIT should permit the development of a whole range of extra-school training.

3. NIT should permit the development of many forms of extra-school training

97. In the first place there is the case already mentioned of initial training outside the school thanks to distance learning. This is in fact the only way of supplying education to three types of public:

i) Seriously handicapped people who cannot travel regularly;

ii) Isolated people who cannot attend school because of geographical distance, difficult travel conditions or ethnic peculiarities that make integration into a "normal" school difficult or undesirable. It is certainly possible to conceive of boarding schools for such people but apart from the fact that this solution is likely to be extremely costly, there are many other disadvantages -- prolonged absence from home, the grouping of individuals who do not know one another and are not always of the same culture, etc.

iii) Those excluded by failure from the school system who want to take up their education again but do not have the time or the inclination to go back to school.

98. New technologies can greatly improve the traditional methods of distance teaching (correspondance courses, radio and/or television broadcasts, cassettes, etc.) thanks to their interactive nature which allows dialogue with the machine, a tutor and other pupils.

99. New information technologies are also an ideal way of developing training for adults. Retraining and refresher courses can be tailored to individual needs to the extent that many programs or simply up-to-date information on a specific subject area can be accessed through equipment in the home at a time to suit the user. They also enable the same program to be supplied to geographically dispersed groups that could be brought together only at considerable cost. They allow training activities to be run at the place of work in line with the needs of the firms or organisations concerned. Lastly, they can respond to many different types of demand not of a directly professional nature, thus facilitating access to culture for large segments of the population. When the extent of unsatisfied demand in this area is known, then the importance of this potential function of new technologies can be appreciated.

100. Lastly, NIT can permit the development of contacts and the interchange of information and opinions between individuals or groups interested in the same problems. The development of interactive man/machine communications should thus in fact enable human contacts to be improved and multiplied, rather than leading to the isolation of the individual.

101. The possibilities offered by these new technologies, so far exploited only to a very limited extent, are thus apparently very considerable, so that it seems quite justifiable to talk of a revolution and a discovery as important as that of printing. But it is important to remember, first, that at best this is a potential that needs a favourable environment to become reality, and second, that this potential is as seen by the supporters of new technologies, who are perhaps not always totally objective and may sometimes be over-optimistic, in particular through ignoring certain potentially negative effects.

B. EFFICIENT USE OF NIT -- CONDITIONS REQUIRED AND LIMITATIONS

102. Computerised instruction systems can be fully effective only if new technologies are introduced on a large scale, if they are sufficiently user-friendly and if they can be used to access information. What is more, the result will depend on how educational institutions and their members adapt to this major innovation. In addition, positive effects may be more limited than envisaged and unexpected negative effects could appear.

1. Environmental conditions required for effective use of NIT

103. Certain conditions need to be fulfilled by the technical instruments themselves. It may appear superfluous to say that these machines can be effective only if the pupils know how to use them, but it must be remembered that the critical mass of hardware is still far from having been reached in the vast majority of countries. As was seen in Chapter II, a very small percentage of establishments possessed even a minimum number of microcomputers in 1982-83 and, in most countries, the effort planned for the newt few years will not be enough -- often far from it -- to reach the minimum rate of equipment required for the really efficient use of NIT, particularly as a substantial proportion of the microcomputers at present in use are not

powerful enough to allow real interactive work and that other handware has not developed as fast as microprocessors. There thus remains a very great deal to be done before all pupils can be offered all the possibilities opened up by NIT. As long as this level of equipment has not been reached, only a fraction of the potential of these machines can be used and there is a risk of creating dangerous inequalities between pupils and establishments if the equipment is unevenly distributed.

104. In the second place, efficient use of the hardware is possible only if there are simple languages to enable the pupil to converse with the machine and if very effective teaching software creates a truly interactive environment. The fact is that, as is well known, the first languages developed for computers required too great a capacity for abstraction and much too long a training for them to be accessible to all pupils of all ages. Considerable progress has been made but two serious faults still remain:

i) First, there is no simple universal language that can be used interchangeably on all types of machine. All too often the information contained on magnetic storage media cannot be directly transferred to a different type of computer;

ii) Second, even if there is confidence that one day -- soon we hope -- direct voice communication with the computer will be possible, this is still at present in the realm of science fiction except for very limited applications.

105. Educational software, too, is improving, but here again it can be seen that the increase in quality is by no means keeping pace with that in quantity. In the United States, for example, a recent study found that of the 4 000 teaching packages available there were probably only 3 or 4 per cent of acceptable quality. Another study found that even after careful prior selection the schools in one Long Island district still ended up with over one-third "junk" (28). This opinion seems to be shared by all the experts. The main reason is that, as pointed out by Y. Le Corre and J. Schwartz, educational software is at present mainly produced by "amateurs" (29). It is well known that the production of high quality educational software requires very varied skills and not only a good knowledge of the material to be taught and of programming. These skills cannot all be found in one individual so that it is necessary to form well-knit teams with each member contributing his know-how and being able to understand the problems and proposals of the others. We are thus still far from having the ideal type of software and full interactivity. There is still a long way to go before such systems become fully effective.

106. Thirdly, the efficient use of the computer/communications potential depends on free access to data banks and on the quality of these banks. If the teacher is to really enrich his courses, he needs access to precise, detailed and up-to-date information. He needs to be able to have rapid access to many more inconographic documents than are available in the manuals. It is therefore essential:

i) To have very complete and well-organised data banks. This is certainly not the case at present, most existing banks being relatively incomplete, covering only certain aspects of the information required for teaching, and difficult to assess.

Considerable progress has been made in the past few years, but much more is required in the near future if data banks are to make a real contribution;

ii) For educational establishments to have access to data banks and audiovisual archives free or at very low cost. The cost problem is connected with that of intellectual property and the legal aspects are complex. If these problems are not resolved, one of the major potential advantages of computerised education systems will not be fully realised (30).

107. Even if the hardware, software and information sources exist, however, the school system has to be organised to make use of them and teachers have to be willing to do so.

108. Certain conditions have to be fulfilled by the educational system and its members. The full potential of NIT cannot be exploited without profound changes in the organisation of the school system and its establishments. The optimum structure in an education system where the means of communicating knowledge, know-how and attitudes are the teacher's words and a piece of chalk is not necessarily well-suited for a system where new technologies occupy a central place. It is necessary to adapt the curriculum so as to integrate educational technology and just how this should be done is not yet fully understood. Earlier experience with audiovisual aids, generally under-utilised or poorly utilised -- if not just consigned to a cupboard -- because it was not known how to integrate them into teaching, should provide food for thought.

109. It is also necessary for the school to take account of the increasing number of home computers in order to guide parents in their educational uses and ensure complementarity with school work if the children's interest is not to be snuffed out by difficulty of access to the school computer or by its limited capabilities.

110. It is also essential that administrators and teachers be prepared to integrate these new systems into their activities. In any event, this implies first of all a very substantial retraining effort. This is an enormous task as large numbers of people are involved and there are still very few qualified instructors. It is therefore necessary to start by training instructors to train instructors before these latter can train new teachers and administrators and retrain those already at work. As we have seen, not only will this essential operation be very costly, but it will also take time, which will further delay the full effective use of these new technologies. Furthermore, there is a real risk of a lack of co-ordination between the acquisition of hardware and the training of staff and hence problems of adaptation for the latter if the hardware is not identical to that on which they trained.

111. Another condition -- all too often considered to be already fulfilled -- is that staff should be willing to exploit the potential offered by these machines. It has to be admitted that they revolutionise normal practices and call traditional teaching methods into question. They may very well be perceived as a threat, as occupying pride of place, performing the functions of the teacher who is now reduced, like a factory worker, to a machine minder. There are even grounds to fear that resistance may be greater

on the part of the majority of "good" teachers, who do well with traditional methods and perhaps do not see what real improvements new technology could bring to their teaching, than on the part of not-so-good teachers who might be only too happy to let the machine do what was previously their job. Hence the importance of proper retraining with insistance on the new opportunities for the teacher opened up by these new tools and the possibility of handing over to them at least some of the more routine and less interesting tasks.

112. It can thus be seen that harnessing the potential of NIT will not be easy. Difficulties will have to be faced and there will always be a substantial gap between this potential and the actual results obtained with the machines. It will also be necessary to guard against the development of unexpected negative effects.

2. Limits on and possible dangers of the large-scale introduction of NIT in education

113. Some of the positive effects claimed by the advocates of introducing NIT in education are by no means proven and/or it is even possible to put forward arguments to prove the contrary. What is more, certain possible negative effects are just not mentioned.

114. Greater equality in the conditions of schooling is by no means certain. It is claimed that using NIT enables shy pupils, slower ones, the handicapped, those rejected by the traditional system and those whose cultural environment is furthest removed from that of the school to improve their performance and approach that of the more favoured pupils. There is certainly evidence to support this theory, but these positive effects can be achieved only if:

i) Schools in poor districts are as well equipped and the teachers as well trained as those in rich districts. Some United Kingdom studies show that this is not always the case and that there is in fact a tendency to introduce new technologies to reduce costs in "poor" districts and to enrich teaching in "rich" districts;

ii) Advantage is taken of the possibilities offered by these instruments to provide remedial teaching for pupils who need it;

iii) Inequalities in home microcomputer ownership does not result in pupils belonging to such households tending to monopolise the school equipment through their being able to learn to use it quickly and efficiently.

115. It is also claimed that the introduction of NITs should make the teacher's job more interesting and free him from a number of routine and boring tasks. But this will be true only if all the possibilities of these machines are exploited by the school and provided the teachers are able and willing to use them. Two negative effects may develop:

i) Differentiation between teachers attracted by computer technology and enthusiastic about its efficient use and others, more attracted by direct human contact, who feel threatened and diminished by these machines;

ii) Differentiation between those who produce the software and develop new audiovisual "manuals" and those who are reduced to merely "accompanying" a message designed by others.

116. Lastly, it is claimed that the widespread use of NIT should favour exchanges and contacts between individuals. The fact is that nothing could be less certain. On the contrary, there seems to be a tendency on the part of individuals fascinated by electronic games and computers to become isolated from others. At best, the new contacts that develop are long distance ones through communications media and are not true human contacts. The machine tends to favour the development of intellectual capacities, sometimes at the expense of affective ones. In our opinion this represents a real danger and every effort must be made to combat it.

117. The internal effects of introducing NIT in education are thus potentially very substantial and for the most part positive, but this potential will not be realised automatically and certainly not immediately. What is the situation with regards to external effects?

Section 3:

THE EXTERNAL EFFECTS OF INTRODUCING NIT IN EDUCATION

118. This concerns the impact on the situation of people once they have been trained by these methods. A distinction is made between three cases:

A. TRAINING WITHIN THE TRADITIONAL EDUCATIONAL SYSTEM

119. Certification is in principle the same as in traditional education. When the two types of education coexist, all that matters is that potential employers should not differentiate between the two or should prefer NIT-based training. There can nevertheless be some hesitation and even rejection at first, especially if the methods are not yet fully developed. The precedent of the television education system in Ivory Coast, which has just been abandoned because of hostility on the part of parents, should be borne in mind.

B. TRAINING OUTSIDE THE TRADITIONAL EDUCATIONAL SYSTEM LEADING TO A DIPLOMA

120. Everything depends on whether the diploma awarded is recognised (either by the authorities or, where there are no national diplomas, by employers) as being equivalent to one awarded by the traditional education system. If this is not the case, the external efficiency of this type of training is low.

C. NON-DIPLOMA COURSES FOR FURTHER TRAINING OR PERSONAL SATISFACTION

121. If the aim is personal satisfaction, the problem does not arise. If the further training is intended to provide additional skills recognised by the employer, everything depends on the latter's attitude. Prior agreement can ensure high external efficiency.

*
* *

Conclusion

122. Potentially, the internal efficiency of educational systems using NIT is very high, but their practical efficiency is largely governed by the care with which the system is set up, and specially as regards courseware. At the moment, practical efficiency is still not very high, as confirmed in the preface to the consolidating report on the symposium held at Pittsburgh in March 1983 (Computers in Education: Realising the Potential), which states that: "The computer is perhaps the most exciting potential source of educational improvement in centuries. Although most currently available applications for schools are mediocre, the possibilities for significant uses are impressive." There is as yet no guarantee of external efficiency where the training leads to the award of a diploma, but in the other cases it is bound to be very high.

GENERAL CONCLUSIONS

123. At the end of this study it is perhaps worthwhile to recall the main outstanding problems and formulate some recommendations.

Outstanding problems:

124. Information about costs is fragmentary and not well-suited for rational economic analysis:

-- Studies on the cost of NIT-based education virtually never use the same units of measurement so that their comparability is considerably impaired;

-- The studies deal with a given point in time so that the information provided is often only of historical interest because of rapid changes in the price of some types of hardware. Longitudinal studies enabling forecast and actual costs to be compared and trends in the operating costs of a programme to be followed are sadly lacking;

-- Some costs are infrequently and inaccurately measured. This is particularly true of maintenance costs and the cost of retraining teachers;

-- There is ambiguity concerning the cost of microcomputers. It is generally difficult to know whether the figure given is the cost of production or the sales price and whether it covers the computer only or includes the peripherals.

125. The costs involved in adapting the school to the introduction of NIT are generally not measured:

-- The costs of installing the equipment, including any modification of the premises, are virtually never mentioned in the studies;

-- The operation costs of the installation are also rarely mentioned;

-- The impact of introducing NIT on personnel costs is passed over in silence, despite its potentially great importance.

126. Future cost trends are estimated in an approximate and often biased fashion:

-- Forward studies are generally based on hardware only;

-- there is a marked tendency to extrapolate past trends without first analysing the causes of, and limits to, the falling costs observed in the recent past;

-- The structural effects of large-scale introduction and their impact on costs are not mentioned.

127. The effects of introducing NIT in education are very unevenly documented:

-- The impact on teachers has been inadequately measured;

-- The effects on pupil attitudes have not received sufficient in-depth study.

128. There is an unfortunate tendency to confuse potential and actual effects:

-- Extrapolating the results of the evaluation of pilot schemes -- well-endowed with resources and run by highly motivated groups -- to the whole of the education system is dangerous;

-- Evaluation generally concerns situations where the minimum threshold for the efficient use of NIT has already been reached. The effects of having just one or two microcomputers in a school have not been seriously examined.

129. Certain effects are claimed but have not been empirically checked. This is true in particular of the equalising effect on pupils.

130. The potential negative effects are systematically passed over in silence:

-- Marginalisation of teachers whose role could be reduced to "machine-minding";

-- Development of negative attitudes on the part of the "best" teachers.

These observations lead to a number of conclusions:

131. Cost studies should:

i) As far as possible be standardized; Costs should be measured per contact hour and/or per teaching programme;

ii) The method should be described and the evaluation should be broken down according to the different components of the system;

iii) Try to be exhaustive and not simple evaluate hardware costs:

-- The least understood and potentially most important costs, such as maintenance and teacher retraining, should be given priority in research studies;

-- The effects on staff costs of introducing NIT should also be examined as a matter of priority;

-- It is necessary to distinguish between the cost of producing equipment and the price paid by educational establishments;

-- Longitudinal studies of projects should be carried out.

132. Measurements of efficiency should:

i) Be carried out more often;

ii) Consider the affective impact on pupils and the effects on teachers' attitudes;

iii) Examine the extent of negative effects.

-- Priority should be given to measuring the threshold effects of gradually introducing NIT and the minimum contact time necessary to achieve full efficiency.

Cost effectiveness studies

133. It is essential that costs and efficiency should not be considered separately but rather in terms of cost-efficiency ratios and trends therein.

NOTES AND REFERENCES

1. Some of these figures differ from those provided by the OECD. The trend is nevertheless the same in the two series except in the case of Belgium for which the OECD gives 63.6 per cent in 1979 (as against UNESCO's 74.2).

2. Detailed data can be found in: J.C. Eicher, D. Hawkridge, E. McAnany, F. Mariet, F. Orivel: The Economics of New Educational Media. Vol. 3: Cost and Effectiveness Overview and Synthesis, UNESCO, 1982.

3. Ludwig Braun: "Report on Educational Technology". Journal of Educational Technology Systems. Vol. 12(2), 1983-84, p. 127.

4. Yves Le Corre: Undated mimeographed document.

5. It if is a matter of training for adults or individual distance-learning at home, it is obviously possible to reduce this cost by working in the evening or early in the morning.

6. cf. for example Ray Reddy: Technologies for Learning. Carnegie. Mellon University. Undated document.

7. cf. Jacob Schwartz: Thoughts on Computer-Aided Instruction. New York Univerisity. Undated document.

8. The detailed reasoning can be found in: La Lettre du CEFI, n° 25, op. cit. 1983.

9. Another United States' evaluation (Strategic Incorporated) goes in the same direction since it considers that the cost-efficiency ration should improve by about 20 per cent a year between 1983 and 1990 while the average price of a microcomputer will probably fall by only $2 000 to $1 000 over the same period.

10. Jacob Schwartz, op. cit., gives division by four as an order of magnitude.

11. CEFI letter n° 25, op. cit.

12. Here again, however, a lack of concordance between the evaluations can be seen, as another French source assesses maintenance at only 8 per cent of investment cost, i.e. about one quarter the depreciation over three years.

13. Idem p. 1.

14. This is the usual official figure. Some authors put forward a significantly lower figure, however.

15. More detail is to be found in some of the background documents for the OECD Conference.

16. A. Melmed: Educational Productivity, The Teacher and Technology, mimeographed document, U.S. Department of Education, Washington, Nov. 1983, p. 3 and 4.

17. Arthur Melmed, op. cit.

18. It is interesting to note that B. Schwartz (l'Informatique et l'Education, 1981) obtains comparable orders of magnitude.

19. cf. The synthesis study by J.A. Kulik and R.L. Bangert-Drowns: "Effectiveness of Technology in Precollege Mathematics and Science Teaching", Journal of Educational Technology Systems. Vol. 12(2), 1983-84, p. 137 to 157.

20. cf. M. Ragosa, P.W. Holland and D.T. Jamison: Computer Assisted Instruction and Compensatory Education: The ETS/LAUDS Study. Mimeographed report, June 1982.

21. The authors consider, however, that these findings are less reliable than those concerning mathematics.

22. A.J. Gaserud: Improving the learning process of correspondance students by use of computers. Report to the Joint Council of the European Council for Education by Correspondance (CEC) and the European Home Study Council (CHSC), Paris, April 1982.

23. S.S. Hartley: Meta-Analysis of the Effects of Individually Paced Instruction in Mathematics. Doctoral thesis, University of Colarado, 1977.

24. cf. The examples cited by J.K. Kulick and R.L. Bangert-Browns, op. cit., p. 153. The effects appear to be more marked in higher education than at secondary level.

25. cf. G. Bracey: Computer-Assisted Instruction: What the research says and does not say and can't say about its effectiveness. University of Virginia. Mimeographed document. The author notes in particular the beneficial effecs on slower or handicapped pupils who regain confidence in themselves when they can work at their own rate without being reprimanded.

26. L. Braun, op. cit., p. 126.

27. For a more in-depth discussion of the profound changes to be expected in the organisation of education and in higher education curricula, see: Samuel L. Dunn: "The Changing University: Survival in the Information Society". The Futurist, vol. XVII, n°4, August 1983, pp.55 to 61.

28. Studies cited by L. Braun, op. cit., p.126.

29. cf. Their report for the OECD Conference [CERI/NT/84.05], dealing with software and courseware for a multimedia educational environment, which gives a very detailed analysis of the conditions required for producing good courseware and the characteristics of a "good" language for pupil/machine communication.

30. It can be seen, for example, how much the ancient history lesson given as an example in paragraph 11 of the report by Y. Le Corre and J. Schwartz depends on free access to many different iconographic documents and film sequences.

Annex 1

THE PROBLEMS OF MEASURING EDUCATION COSTS AND THE NECESSARY METHODOLOGICAL CHOICES

1. Available data concern expenditure, not costs. This is usually public expenditure and even merely forward estimates set out in final budgets. International bodies could and should play a major role in the search for more reliable data.

1. Importance of the Distinction Between Cost and Expenditure

2. Economists seek to determine optimum allocation of scarce resources. The cost of an activity or good is represented by the value of the opportunities which have had to be foregone. The expenditure committed with a view to providing an activity or creating a good therefore sometimes has to be augmented by the cost of what is foregone.

3. Potentially, each pupil pursuing studies beyond compulsory schooling and each adult following a training course during normal working hours lower output by the equivalent of their work input. The same applies to any extension of compulsory schooling. Any allocation of additional resources to education therefore involves foregoing other goods or other satisfactions. The expenditure observed constitutes a yardstick (albeit imperfect) for only part of the value of the resources used and hence of the sacrifices made, i.e. of the cost of education.

4. Education forms part of public goods. In fact, however, this merely means that a large share of the direct cost is borne directly by the community. Data on the expenditure by the various groups concerned (government, local communities, business, households, etc.) provide an inaccurate picture of the breakdown of the efforts made by each party towards education inasmuch as the costs of what is foregone are shared among them in different ways.

2. Expenditure

5. The amounts spent on education come from various sources. Generally the greater share comes from public sources:

a) Public Expenditure

6. This is shared between the central or federal government and regional or local authorities.

i) Central government: alongside the ministry (or ministries) of education, other government departments also financing educational activities have to be taken into account.

ii) Local authorities: Local authority expenditure on education is often sizeable but not always easy to identify as it does not (or not always) figure under specific budget heading.

iii) External public aid: In the less-developed countries this is sometimes very high but in OECD countries it is usually non-existent or negligible.

b) Private Expenditure

7. This comes mainly from students and/or their families, but business is playing an increasing role, especially for financing further training. In some countries, a third group -- sponsors -- may play an important role in higher education and research.

8. Students and their families: Their education expenditure covers not only enrolment and tuition fees but also all the outgoings entailed in student life: educational supplies, but also transport, clothing, food, etc. It is therefore difficult to evaluate since in most cases it is a matter of identifying net balances (which may even be negative if some expenditure is highly subsidized) in households' "ordinary" expenditure. The increasing use of modern teaching aids (e.g. mini-computers) may possibly shift costs over to families if the pupils themselves acquire this type of equipment.

9. Business: This type of financing concerns not only training organised within a specific and regulated institutional framework but also further training provided at the enterprise's instigation within its own premises, sometimes in the form of on-the-job training. The latter type of expenditure is much more difficult to measure than that for institutionalised training.

10. Sponsors: In quantitative terms their contribution is small but it may prove decisive where a new programme is to be launched or an innovative investment is to be made.

3. Available Data and Their Limitations

a) Almost everywhere available data are incomplete:

11. Official data merely concern expenditure. There are few reliable studies on costs, accurate data on household expenditure are available in only very few countries and never cover long periods, even in the case of public expenditure, local authorities' expenditure is rarely properly measured. They are generally underestimated.

b) Available data are not always very reliable:

12. Data on public expenditure usually come from budget documents and concern estimated expenditure (final budgets) and not the amounts actually spent (financial accounts). Data from different sources do not always correspond (calendar year/fiscal year, account taken/not taken of all ministries involved, different evaluation of local authority expenditure, etc.).

TRENDS IN GOVERNMENT EXPENDITURE ON EDUCATION
(% of GNP spent on public education)
IN SELECTED OECD COUNTRIES (1970-81)

COUNTRY	1970	1972	1974	1976	1978	1980	1981
Australia	4.17	4.63	6.02	6.16	6.06	5.77	-
Denmark	7.08	7.60	7.94	7.57	7.49	-	-
France	-	-	-	5.82	5.81	-	-
Italy	4.46	5.09	4.62	4.97	5.11	5.60	6.40
Japan	3.57	3.96	4.66	4.85	4.98	4.97	4.96
Netherlands	7.00	7.19	7.39	7.70	7.81	-	-
Germany	4.03	4.66	5.16	5.05	4.93	5.14	-
United Kingdom	5.34	5.77	6.02	6.40	5.78	-	-
U.S.A.	5.29	5.78	5.93	6.12	5.72	-	-

Source : OECD - National accounts.